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(71) Applicant *(for all designated States except US)*: THE OHIO STATE UNIVERSITY RESEARCH FOUNDATION [US/US]; 1960 Kenny Road, Columbus, OH 43210 (US).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)* : STEVENS, Vernon, C. [US/US]; 5489 River Forest Road, Dublin, OH 43017 (US).

(74) Agent: MILLARD, Sidney, W.; Kremblas, Foster & Millard, 7632 Slate Ridge Boulevard, Columbus, OH 43068-3126 (US).

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(57) Abstract

A vaccine, useful for fertility control and cancer treatment, comprises an antigenic conjugate of a protein reproductive hormone, a fragment of such a hormone, or a peptide substantially immunologically equivalent to such a hormone or fragment conjugated with a chemically-modified diphtheria toxoid, and an adjuvant both dispersed in an aqueous medium and emulsified with a mixture of oils. An antigenic conjugate which can be used in this or a similar vaccine, comprises a protein reproductive hormone, a fragment of such a hormone, or a peptide substantially immunologically equivalent to such a hormone or fragment, coupled to an epitope peptide having the sequence of at least one T cell lymphocyte epitope of a protein foreign to the animal to be treated with the conjugate, or a sequence substantially immunologically equivalent to such an epitope.

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VACCINES AND ANTIGENIC CONJUGATES

This invention relates to a vaccine comprising an antigenic conjugate of a protein reproductive hormone, and to an antigenic conjugate of a protein reproductive hormone comprising an epitope peptide.

In the present inventor's United States Patents Nos. 4,201,770; 4,302,386; 4,384,995; 4,526,716; 4,691,006; 4,713,366; 4,855,285; and 5,006,334; in his copending Applications Serial Nos. 07/390,530 and 07/311,331 filed August 7, 1989 and February 17, 1989 respectively; in his International Patent Application PCT/US83/00777; and in his numerous corresponding patents and applications in other countries, there are described and claimed antigenic polypeptides which are obtained by coupling a female protein reproductive hormone, a fragment of such a hormone, or a peptide substantially immunologically equivalent to such a hormone or fragment, to a non-endogenous material having a size sufficient to elicit antibody response following the administration thereof into the body of a human or other mammal. When administered to humans or other mammals, these antigenic polypeptides cause the development of antibodies to the female protein reproductive hormone from which they are derived, and the antigenic polypeptides are thus useful for controlling biological activity in humans or other mammals. The biological activity controlled can be, inter alia, fertility or the development of malignant tumors. In a preferred form of such antigenic polypeptides, the carrier is diphtheria toxoid. The aforementioned patents and applications, the contents of which are herein incorporated by reference, also disclose vaccines containing the antigenic polypeptides together with an adjuvant and an oil, the antigenic polypeptide and the adjuvant being dispersed in an aqueous medium to form an aqueous phase and this aqueous phase being emulsified with the oil.

This invention provides an improved form of the vaccine described in the aforementioned patents and applications. This invention also provides an antigenic conjugate of a protein reproductive hormone which is generally similar to the conjugates described in the aforementioned patents and applications but which uses a different type of non-endogenous material.

In one aspect, this invention provides a vaccine comprising an antigenic conjugate of a protein reproductive hormone, a fragment of such a hormone, or a peptide substantially immunologically equivalent to such a hormone or fragment; an adjuvant; and at least one oil, the conjugate and adjuvant being dispersed in an aqueous medium to form an aqueous phase and this aqueous phase being emulsified with the oil(s). This vaccine is characterized in that the antigenic conjugate comprises the hormone, fragment or peptide conjugated with a chemically-modified diphtheria toxoid, and the aqueous phase is emulsified with an oil or mixture of oils.

This invention also provides a process for generating antibodies to a protein or reproductive hormone and/or for generating lymphoma cells capable of expressing such antibodies by administering to a mammal a vaccine of the invention and recovering the antibodies and/or lymphoma cells from the mammal. The invention extends to antibodies to a protein or reproductive hormone, lymphoma cells capable of expressing such antibodies, and hybridoma cells derived from lymphoma cells generated by this process.

This invention also provides the use of such a vaccine for treating humans suffering from a malignant disease.

In another aspect, this invention provides an antigenic conjugate of a protein reproductive hormone, a fragment of such a hormone, or a peptide substantially immunologically equivalent to such a hormone or fragment, this conjugate being characterized in that the hormone, fragment or peptide is coupled to an epitope peptide having the sequence of at least one T cell lymphocyte epitope of a protein foreign to the animal to be treated with the conjugate, or a sequence substantially immunologically equivalent thereto.

This invention provides the use of such an antigenic conjugate to control fertility, or treat a malignant disease, in humans.

This invention also provides a process for preparing antibodies to a protein reproductive hormone, or lymphoma cells capable of expressing such antibodies, which process comprises introducing into a mammal a modified

polypeptide, thereby causing the formation of the antibodies in the mammal, and recovering the antibodies or lymphoma cells from the mammal. This process is characterized in that the modified polypeptide used is an antigenic conjugate of the present invention. The invention extends to antibodies to a protein or reproductive hormone, lymphoma cells capable of expressing such antibodies, and hybridoma cells derived from lymphoma cells generated by this process.

This invention also provides a process for determining the presence or absence of a protein in a mammal, or assaying the quantity of a protein in a mammal, which process comprises bringing body tissue or fluid from the mammal into contact with an antibody capable of reacting with the protein, and observing the formation or non-formation of a complex between the antibody and the protein. This process is characterized in that the antibody used is produced by the process defined in the preceding paragraph.

Finally, this invention also extends to the use of an antibody produced by the process defined above to treat disease in a mammal.

Figure 1 shows the formulae of three coupling agents used to prepare the conjugates of the present invention; and

Figure 2 shows a typical reaction used to prepare conjugates of the present invention, together with examples of the modified polypeptides produced by such conjugation reactions.

As already mentioned, the present invention provides a vaccine comprising the antigenic conjugate of a protein reproductive hormone conjugated with a chemically-modified diphtheria toxoid. The vaccine also comprises an adjuvant and a mixture or oils. To form the vaccine, the conjugate and adjuvant are dispersed in an aqueous medium, preferably phosphate-buffered saline, to form an aqueous phase and this aqueous phase is emulsified with the mixture of oils.

As compared with the inventor's earlier vaccines described in the aforementioned patents and applications, the vaccine of the present invention exhibits an improved ability to attract immune cells to the injection site, and thus to generate the desired antibody response from the human or other animal being treated.

Preferred embodiments of the present vaccine also form a thick emulsion which slowly releases the antigenic conjugate from the injection site, thus providing a desirable long term development of antigenic response.

Diphtheria toxoid suitable for use in the vaccines of the present invention is available commercially, for example from Connaught Laboratories, Swiftwater, Massachusetts; such diphtheria toxoid may be reacted with ethylenediamine as described below. The ratio of reproductive hormone, fragment or peptide to conjugate in the vaccine can vary widely, but desirably, the antigenic conjugate comprises 20-30 peptides per 10^5 daltons of the chemically-modified diphtheria toxoid.

A preferred adjuvant for use in the vaccines of the present invention is N-acetyl-D-glucosamine-3-yl-acetyl-L-ala-D-isoglutamine (nor muramyl dipeptide), while a preferred mixture of oils comprises squalene and squalane, desirably containing one or both of mannide monooleate and dissolved or suspended aluminum monostearate. Preferably, such a mixture comprises, by weight, from 35 to 45 percent of squalene, from 35 to 45 percent of squalane, from 6 to 16 percent of mannide monooleate and from 1 to 5 percent of aluminum monostearate, with a specific preferred formulation being 44 percent squalene, 41 percent squalane, 11 percent mannide monooleate and 4 percent dissolved or suspended aluminum monostearate. Although the ratio of the various constituents of the vaccine can vary widely, desirably, from about 0.5 to about 2.0 mg of the antigenic conjugate and from about 0.2 to about 1.0 mg of the adjuvant are present per ml of the final emulsion. Conveniently, the vaccine comprises substantially equal volumes of the aqueous phase and the mixture of oils.

The vaccines of the present invention can be used for any of the purposes described in the aforementioned patents and applications, including fertility control. However, the present vaccines are especially useful for the treatment of humans (or other animals) suffering from a malignant disease, for example breast cancer, lung cancer, colon cancer, malignant melanoma or bladder carcinoma.

The vaccines of the present invention have been found effective in attracting immune cells to the site of the injection, while the physical nature of the vaccine, which is a thick emulsion, also helps to ensure a slow release of the conjugate.

Also as already mentioned, the present invention provides an antigenic conjugate of a protein reproductive hormone, a fragment of such a hormone, or a peptide substantially immunologically equivalent to such a hormone or fragment coupled, typically at either its N-terminal or its C-terminal, to an epitope peptide having the sequence of at least one foreign T cell lymphocyte epitope, or a sequence substantially immunologically equivalent thereto. Conjugates formed with T cell epitopes tend to be cheaper to produce than the conjugates formed with complex carriers such as diphtheria toxoids described in the aforementioned patents and applications. Furthermore, because the T cell epitopes are much simpler in structure than diphtheria toxoid and similar complex carriers, T cell epitope conjugates are less likely to provoke hypersensitivity reactions. Until recently, the use of T cell epitopes in conjugates was counterindicated because genetic variations in outbred populations of humans or other animals responded to different T cell epitopes on foreign molecules, and when only a single T cell epitope was provided (as would normally be the case when using an antigenic conjugate) not all of the animals treated gave positive responses, thus rendering the T cell epitope conjugate unreliable. However, recently certain T cell epitopes from foreign molecules have been shown not to be limited by such genetic restrictions, and the use of these T cell epitopes enables the preparation of conjugates and vaccines which give reliable antibody responses in genetically-diverse populations of humans and other animals. See, for example, Ho et al., Eur. J. Immunol., 20, 477-483 (1990), and Partidos et al., J. Gen. Virology, 71, 2099-2105 (1990).

Preferred epitope peptides for use in the conjugates of the present invention are those having a sequence corresponding to, or substantially immunologically equivalent to:

a. amino acids 580-599 of tetanus toxoid:

Asn-Ser-Val-Asp-Asp-Ala-Leu-Ile-Asn-Ser-Thr-Lys-
Ile-Try-Ser-Tyr-Phe-Pro-Ser-Val

b. amino acids 830-844 of tetanus toxoid
Gln-Try-Ile-Lys-Ala-Asn-Ser-Lys-Phe-
Ile-Gly-Ile-Thr-Glu-Leu

c. amino acids 916-932 of tetanus toxoid:
Pro-Gly-Ile-Asn-Gly-Lys-Ala-Ile-His-Leu-Val-
Asn-Asn-Gln-Ser-Ser-Glu

d. amino acids 947-967 of tetanus toxoid:
Phe-Asn-Asn-Phe-Thr-Val-Ser-Phe-Trp-Leu-Arg-
Val-Pro-Lys-Val-Ser-Ala-Ser-His-Leu-Glu

e. amino acids 288-302 of measles virus protein:
Leu-Ser-Glu-Ile-Lys-Gly-Val-Ile-Val-His-Arg-Leu-Glu-Gly-Val

f. amino acids 16-33 of hepatitis B viral protein:
Gln-Ala-Gly-Phe-Phe-Leu-Leu-Thr-Arg-Ile-Leu-Thr-Ile-Pro-Gln-Ser-Leu-Asp

or

g. amino acids 317-336 of malaria CSP protein:
Thr-Cys-Gly-Val-Gly-Val-Arg-Val-Arg-Ser-
Arg-Val-Asn-Ala-Ala-Asn-Lys-Lys-Pro-Glu.

As discussed in more detail below, the epitope peptide may be coupled directly to the hormone, fragment or peptide used to form the conjugate, or the coupling may be effected via a spacer peptide, this spacer peptide preferably containing from about 2 to about 8 amino acid residues.

Like the vaccines of the present invention the T cell epitope conjugates of the present invention can be used for any of the purposes described in the aforementioned patents and applications, including fertility control, or the treatment of humans (or other animals) suffering from a malignant disease, for example breast cancer, lung cancer, colon cancer, malignant melanoma or bladder carcinoma. In some cases, it may be advantageous to use a mixture of two or more

T cell epitope conjugates for this purpose in order to secure improved antibody production.

Many of the preferred features of the vaccines and antigenic conjugates of the present invention are generally similar to those described in the aforementioned patents and applications. Accordingly, while these preferred features will be discussed below, the reader is referred to these patents and applications for additional information.

The protein reproductive hormone, a fragment of such a hormone, or a peptide substantially immunologically equivalent to such a hormone or fragment may be of natural or synthetic origin. A synthetic hormone molecule will perform the same function as the naturally occurring one, being equivalent for the purpose of this invention. In this connection, it will be noted that certain natural substances with which this invention is concerned possess carbohydrate moieties attached at certain sites thereon whereas the corresponding synthetic polypeptides do not. Nevertheless, for the purpose of the instant specification and claims, the synthetic and natural polypeptides are treated as equivalents and both are intended to be embraced by this invention.

Thus, where the word "hormone" or "hormone molecule" is used herein, the word "synthetic" may be added before "hormone" without changing the meaning of the discussion. Similarly, the word "fragment" may be inserted after "hormone" or "molecule" without changing the meaning, whether or not "synthetic" has been inserted before "hormone".

The term "endogenous" is used herein to denote a protein which is native to the species to be treated, regardless of whether the relevant protein, fragment or antigen is endogenous to the particular individual animal being treated. Thus, for example, for purposes of this application, a porcine sperm antigen is regarded as being endogenous to a sow even though obviously such a sperm antigen will not normally be present in the body of a sow. Similarly, an embryonic, fetal or placental antigen of an animal is regarded as being endogenous to an adult animal of the same species even though such antigens may not exist in the body of the

animals after birth. Further antigens produced from an animal's normal cells that have been transformed by mutagenous or other genetic deviation should be considered endogenous to the species in which those cells reside at the time of transformation or deviation.

The antigenic conjugates of the invention, which are derived from endogenous protein reproductive hormones, fragments thereof, or peptides equivalent thereto, provoke, when administered into the bodies of appropriate mammals, antibodies to the endogenous proteins from which the modified polypeptides are derived, and the formation of lymphoma cells capable of expressing such antibodies. Consequently, not only can such conjugates be used to influence the biological activity in a mammal to which they are administered by generating antibodies to an endogenous protein in the mammal, but the conjugates of the invention can also be used to generate antisera and/or lymphoma cells by introducing the conjugates into the body of a mammal, thereby provoking the formation, in the mammal, of antibodies to the "endogenous protein"; note that in such a method, since the conjugate need not be introduced into the same mammal, or even a mammal of the same species, as the animal from which it is derived or, in the case of a conjugate based upon a synthetic fragment, the mammal whose protein it mimics, the so-called "endogenous protein" used in this method need not be endogenous to the mammal in which the antibodies are raised.

Following the raising of the antibodies and/or lymphoma cells in the mammal, some of the antibodies and/or cells may be recovered from the mammal, using conventional techniques which will be familiar to those skilled in the art of immunology. Techniques generating monoclonal antibodies may also be used to generate the desired antibodies; for example, lymphoma cells generated as described above may be used to form hybripma cells capable of expressing the relevant antibodies by conventional techniques which will be known to those skilled in hybridoma technology. The antibodies thus generated can then be used for a variety of purposes. For example, such antibodies may be used for assaying the quantity of an endogenous protein in a mammal by bringing at least some of the recovered

antibodies into contact with body tissue or body fluid from the mammal and observing the formation or non-formation of the reaction process between the recovered antibody and the endogenous protein indicative of the presence or absence of the endogenous protein in the body tissue or body fluid assayed. If, in this method, the endogenous protein assayed is one associated with pregnancy, this assay method can function as a pregnancy test. If, on the other hand, the endogenous protein assayed is one the presence or absence of which is associated with reduced fertility or infertility in the mammal from which the body tissue or body fluid is derived, the assay can function as a test for reduced fertility or infertility in such a mammal.

Selection of Hormone, Fragment or Peptide for Modification

Examples of natural protein reproductive hormones which may be modified according to this invention include Follicle Stimulating Hormone (FSH), Luteinizing Hormone (LH), Luteinizing Hormone Releasing Hormone (LH-RH), relaxin, Chorionic Gonadotropin (CG), e.g. Human Chorionic Gonadotropin (HCG), Placental Lactogen, e.g. Human Placental Lactogen (HPL) and Prolactin, e.g. Human Prolactin. There are certain considerations which should always be borne in mind when considering the selection of an appropriate polypeptide for modification by the techniques of the instant invention. Firstly, it is of course necessary to determine which hormone or combination of hormones or other protein is responsible for the condition or problem which it is desired to treat. However, in many cases this will still leave one with a large number of possible proteins which could be modified by the techniques of the instant invention. For example, if one wishes to use the instant invention to provide a conjugate to render a female mammal infertile, one can approach the problem by modifying FSH, LH, LH-RH, CG, PL, relaxin or other protein hormones which known to be involved in the female mammalian reproductive system. One important consideration which should always be borne in mind in choosing a polypeptide for modification by the instant invention is the problem of cross-reactivity. As well known to those skilled in the field of immunology, it is not uncommon to find that antibodies intended to react with one

protein (the "target" protein) also react to a significant extent with other, non-target proteins. This is a serious problem, since it may cause the administration of a conjugate intended to provoke the formation of antibodies to one specific natural hormone to cause the generation of antibodies to one or more other hormones, which it is not desired to effect. In some cases, the reactions with the non-target proteins may cause damage to essential body functions. Accordingly, so far as possible the hormone, fragment or peptide selected for modification by the instant invention should be chosen so that the conjugate will provoke, in the body of the mammal to be treated, the formation of antibodies which are highly specific to the target protein. In some cases, especially where the target protein is relatively small (for example LH-RH), it may be in practice essential to modify the whole target protein, since a fragment comprising less than the whole target protein, will, even when modified by the instant techniques, fail to provoke sufficient antibodies to the target protein. However, in general, especially when dealing with relatively complex target proteins such as HCG, the use of a fragment of the target protein rather than the intact target protein is recommended for use in forming a conjugate of the instant invention. It is well recognized by those skilled in immunology (see e.g. W. R. Jones, "Immunological Fertility Regulation", Blackwell Scientific Publications, Victoria, Australia (1982) pages 11 et. seq., the entire disclosure of this work is herein incorporated by reference, that one of the greatest potential hazards of a vaccine, especially a contraceptive vaccine, is cross-reactivity with non-target antigens, producing what is essentially an artificially-induced autoimmune disease capable of causing immunopathological lesions in, and/or loss of function of, the tissues carrying the cross-reactive antigens. Two possible mechanisms for such cross-reactivity are:

(a) presence of shared antigenic determinants; a complex target protein may contain components (amino-acid sequences) identical to those present in non-target proteins; and

(b) steric overlap between non-identical but structurally related parts of the target and non-target proteins.

Obviously, the threats posed by both these modes of cross-reactivity may be lessened by using, in the conjugates of the invention, a fragment of a complex protein rather than the whole protein. Since the fragment has a simpler structure than the protein from which it is derived, there is less chance of shared antigenic determinants or steric overlap with non-target proteins. In particular, cross-reactions can be avoided by using fragments derived from a portion of the target protein which is not similar in sequence to the non-target but cross-reactive protein. To take one specific example, one of the major problems in provoking antibodies to HCG is cross-reactivity of HCG antibodies with LH, this cross-reactivity being at least largely due to virtual identity of amino acid sequence between LH and the 1-110 amino acid sequence of the beta subunit of HCG. Accordingly, when it is desired to form an HCG-derived conjugate of the invention, the fragment used is preferably one having a molecular structure similar to part or all of the 111-145 (or, for reasons discussed below, the 109-145) sequence of the beta subunit of HCG, since it is only this 111-145 sequence of beta-HCG which differs significantly from the corresponding sequence of LH. However, as discussed in more detail below, fragments of mammalian luteinizing hormones, chorionic gonadotropins or follicle secreting hormones having amino acid sequences resembling the 38-57 region of the beta-subunit or human chorionic gonadotropin are also useful in the present invention.

Thus, in most cases the polypeptide modified by the techniques of the instant invention is preferably a fragment of the target protein rather than the intact target protein. More accurately, one should use, as the fragment of a polypeptide to be modified by the techniques of the invention, a fragment which has a molecular structure similar to a fragment of the target protein. In saying that the fragment has a molecular structure similar to a fragment of the target protein, it is not necessarily implied that the entire amino acid sequence of the fragment must correspond exactly to part of the sequence of the target protein. For example, in certain cases some substitution of amino acids may be possible without effecting the immunogenic character of the fragment. See the aforementioned U.S. Patent No. 4,302,386, which

describes a polypeptide, designated Structure (IX) (which is also discussed in detail below), which is notionally derived from the beta subunit of HCG but in which the cysteine residue at the 110-position is replaced by alpha-aminobutyric acid. Furthermore, although the natural form of the beta subunit of HCG contains a number of carbohydrate residues attached to the amino-acid chain, synthetic peptides corresponding in sequence to the relevant parts of the HCG sequence, but lacking such carbohydrate residues, can be modified to give conjugates of the instant invention and give good results.

Although species specificity is of course a consideration in any immunological process, the present invention does not exclude the possibility of the hormone, fragment or peptide to be modified may actually be derived from a protein of a different species of mammal than the mammal to which the conjugate is to be administered, since many proteins are either identical between species or differ from one another so little in amino acid sequence that considerable cross-reactivity exists between antibodies to the corresponding proteins of the two species. Also, the fragments modified by the instant processes may incorporate sequences of amino acids having no counterpart in the sequence of the protein from which the fragment is notionally derived. Again, for example, it is shown below that one may use in the instant processes certain polypeptide fragments, designated Structures (IV), (VIII), (IX), (X) and (XIV) which are notionally derived from the beta subunit of HCG but which incorporate spacer sequences comprising multiple proline residues.

Of course, one should be cautious when using sequences not exactly corresponding to portions of the target protein. For example, the protein relaxin is known to be highly species specific and accordingly it is not recommended that fragments of non-human relaxin proteins be modified by the instant methods and injected into humans to provoke the formation of anti-relaxin-antibodies in humans. In choosing an appropriate hormone, fragment or peptide for formation of a conjugate, amino-acid sequence is, however, not the only factor which has to be considered; it is also necessary to pay close attention to the conformation, that is to say the physical shape, of the protein, fragment or peptide selected relative to the

natural conformation of the target protein. It is well known to those skilled in the art of immunology that the conformation or shape of an antigen is an important factor in allowing recognition of the antigen by an antibody. Accordingly, if a conjugate of the instant invention does not retain the conformation of the relevant part of the target protein, it is likely that the antibodies provoked by injection of the conjugate into a mammal will not display optimum activity against the natural target protein. For example, a peptide having the same sequence as part of the target protein will probably not work very well if, because of the absence of other parts of the sequence of the target protein which affect the positioning of the crucial antigenic determinant in the natural target protein, the fragment used to prepare the conjugate adopts a conformation very different from the conformation of the same amino acid sequence in the target protein. Similarly, because of the way in which the chain of a complex target protein will normally be folded, the antigen-antibody binding reaction may rely upon recognition of two or more amino acid sequences which are widely separated along the chain of the target protein but lie, in the natural conformation of the target protein, closely adjacent one another in space. All these considerations may enter into the question of what is the most appropriate hormone, fragment or peptide to use in the instant invention.

As those skilled in the art are aware, one major factor effecting the conformation, and hence the antigenic properties and antigenic determinants, of complex proteins is the presence of cysteine residues and disulfide bridges in such proteins. It is well know to those skilled in the art that, in many natural proteins containing cysteine residues, these residues are not present in their thiol form containing a free -SH group. Instead, pairs of cysteine residues are linked by means of disulfide bridges to form cystine. Such disulfide bridges are very important in determining the conformation of the protein. In most cases, the disulfide bridges present in the natural form of the protein are easily reduced to thiol groups by means of mild reducing agents under conditions which leave the remaining parts of the protein molecule unchanged. Such breaking of disulfide bridges causes major changes in the conformation of the protein even though no disturbance of the amino

acid sequence occurs. In particular, the twelve cysteine residues present in the beta subunit of HCG are, in the natural form of the subunit, coupled together to form six disulfide bridges, so that the natural form of the protein has no free thiol groups.

The generation of free thiol groups by reduction of disulfide bridges in naturally occurring forms of proteins may affect the cross-reactivity of the antibodies produced when a conjugate derived from the protein or a fragment thereof is injected into an animal. As already mentioned, an antibody frequently recognizes its corresponding antigen not only by the amino acid sequence in the antigen but also by the conformation of the antigen. Accordingly, an antibody which binds very strongly to a protein or a peptide in its natural conformation may bind much less strongly, if at all, to the same protein or polypeptide after its conformation has been drastically altered by breaking disulfide bridges therein.

Accordingly, the breaking of disulfide bridges in proteins or other polypeptides may provide a basis for reducing the cross-reactivity between antibodies to antigens having the same amino acid sequence along parts of the molecule. For example, it has been pointed out above that cross-reaction is frequently encountered between antibodies to beta-HCG and HLH because the first 110 residues in the beta-HCG and HLH sequence are virtually identical in the natural forms of the two molecules, thus the conformations are also presumably very similar. It has been suggested above that one means of producing antibodies to beta-HCG in an animal which do not substantially cross-react with HLH is to supply to the animal a conjugate of the invention derived from a polypeptide which contains all or part of the residues 111-145 of beta-HCG but which lacks all or substantially all of the residues 1-110 of beta-HCG. In effect, this approach avoids antibody cross-reaction with HLH by chemically removing from the conjugate the sequence of residues which is common to beta-HCG and HLH. As an alternative approach, by cleaving the appropriate number of disulfide bridges in the natural form of beta-HCG, it may be possible to so alter the conformation of residues 1-110 thereof that the antibodies formed when a conjugate of the invention based upon this altered-conformation beta-HCG is administered to an animal will no longer cross-react significantly with

HLH. In other words, instead of chemically severing the common sequence of residues from beta-HCG in order to prevent cross-reaction, it may be possible to leave this common sequence of residues in the beta-HCG but to so alter the conformation of this common sequence that, to an antibody, the altered-conformation common sequence does not "look" like the natural form of the common sequence, so that an antibody which recognizes the altered-conformation common sequence will not recognize the natural-conformation common sequence in HLH. Moreover, once the natural conformation of the sequence of residues 1-110 has been destroyed by breaking the disulfide bridges, this common sequence will probably assume the helical conformation common in polypeptides lacking disulfide bridges, so that this part of the beta-HCG will not be strongly immunogenic and most of the antibodies formed by a conjugate based upon the altered-conformation beta-HCG will be antibodies to the sequence 111-145 which is not common with HLH. Obviously, cross-reactivity between antibodies to other pairs of hormones may similarly be destroyed by altering the conformation of portions of the two proteins which are similar and hence will otherwise promote antigen cross-reactivity.

At present, the preferred conjugates are those derived from CG (together with those derived from the somewhat similar luteinizing and follicle secreting hormones), and those derived from relaxin.

Chorionic Gonadotropin and Related Hormones

The hormone, Chorionic Gonadotropin (CG) has been the subject of extensive investigation, it being demonstrated in 1927 that the blood and urine of pregnant women contained a gonad-stimulating substance which, when injected into laboratory animals, produced marked gonadal growth. Later, investigators demonstrated with certainty that the Placental Chorionic villi, as opposed to the pituitary, were the source of this hormone. Thus, the name Chorionic Gonadotropin or, in the case of humans, Human Chorionic Gonadotropin (HCG) was given to this hormone of pregnancy. During the more recent past, a broadened variety of studies have been conducted to describe levels of HCG in normal and abnormal physiological states, indicating its role in maintaining pregnancy. The studies have

shown the hormone's ability to induce ovulation and to stimulate corpus luteum function, and evidence has been evoked for showing its ability to suppress lymphocyte action. The immunological properties of the HCG molecule also have been studied widely. Cross-reaction of antibodies to HCG with human pituitary Luteinizing Hormone (LH), and vice-versa, has been extensively documented, see for example:

Paul, W. E. & Ross, F. T., Immunologic Cross Reaction Between HCG and Human Pituitary Gonadotropin. Endocrinology, 75, 352-358 (1964);

Flux, D. X. & Li C. H., Immunological Cross Reaction Among Gonadotropins. Acta Endocrinologic, 48, 61-72 (1965);

Bagshawe, K. D.; Orr, A. H. & Godden J., Cross-Reaction in Radio-Immunoassay between HCG and Plasma from Various Species. Journal of Endocrinology, 42, 513-518 (1968);

Franchimont, P., Study on the Cross-Reaction between HCG and Pituitary LH. European Journal of Clinical Investigation, 1, 65-68 (1970);

Dorner, M.; Brossmer, R.; Hilgenfeldt, U. and Trude, E., Immunological reactions of Antibodies to HCG with HCG and its chemical derivatives in Structure-Activity Relationships of Proteins and Polypeptide Hormones (ed. M. Margoulies & F. C. Greenwood), pp 539, 541 Amsterdam: Excerpta Medica Foundation (1972);

Further, these cross-reactions have been used to perform immunoassays for both CG and LH hormones. See:

Midgley, A. R. Jr., Radioimmunoassay: a method for HCG and LH. Endocrinology, 79, 10-16 (1966);

Crosignani, P. G., Polvani, F. & Saracci R., Characteristics of a radioimmunoassay for HCG-LH in Protein and Polypeptide Hormones (ed. M. Margoulies) pp. 409, 411 Amsterdam: Excerpta Medica Foundation (1969);

Isojima, S; Nake, O.; Kojama, K.; & Adachi, H. Rapid radioimmunoassay of human L. H. using polymerized antihuman HCG as immunoadsorbent. Journal of Clinical Endocrinology and Metabolism, 31, 693-699 (1970).

Although the entire CG hormone or a subunit thereof, for example the beta subunit, may be used in the present conjugate, in general it is preferred to use a peptide corresponding to only a fragment of the beta subunit. More specifically, as already noted there is a large portion of the beta subunit of CG which is almost identical to the corresponding beta subunit of LH, so that it is desirable to use a fragment corresponding to a portion of the 111-145 sequence of the beta subunit of CG which is not common to LH, thereby avoiding the cross-reactivity of CG and LH antibodies already discussed above. Thus, an immunological reaction against the hormone CG can be achieved without causing undesirable immune reactions to the naturally occurring body constituent LH. Synthetic polypeptides corresponding to the desired fragments of CG offer enhanced practicality both from the standpoint of production costs and the high degree of purity needed for commercial use in a contraceptive agent.

Subunits and fragments of the proteinaceous reproductive hormones include the beta subunit of natural Follicle Stimulating Hormone, the beta subunit of natural Human Chorionic Gonadotropin, fragments including, inter alia, a 20-30 or 30-39 amino acid peptide consisting of the C-terminal residues of natural Human Chorionic Gonadotropin beta subunit, as well as specific unique fragments of natural Human Prolactin and natural Human Placental Lactogen, which may bear little resemblance to analogous portions of other protein hormones. Further with respect to the type of novel chemical entities with which this invention is concerned, one may note for instance the chemical configuration of the beta subunit of HCG. That structure is as follows:

Structure (I)

Ser-Lys-Glu-Pro-Leu-Arg-Pro-Arg-Cys-Arg-Pro-

Ile-Asn-Ala-Thr-Leu-Ala-Val-Glu-Lys-Glu-Gly-

Cys-Pro-Val-Cys-Ile-Thr-Val-Asn-Thr-Thr-Ile-
Cys-Ala-Gly-Try-Cys-Pro-Thr-Met-Thr-Arg-Val-
Leu-Gln-Gly-Val-Leu-Pro-Ala-Leu-Pro-Gln-Val-
Val-Cys-Asn-Try-Arg-Asp-Val-Arg-Phe-Glu-Ser-
Ile-Arg-Leu-Pro-Gly-Cys-Pro-Arg-Gly-Val-Asn-
Pro-Val-Val-Ser-Try-Ala-Val-Ala-Leu-Ser-Cys-
Gln-Cys-Ala-Leu-Cys-Arg-Arg-Ser-Thr-Thr-Asp-
Cys-Gly-Gly-Pro-Lys-Asp-His-Pro-Leu-Thr-Cys-
Asp-Asp-Pro-Arg-Phe-Gln-Asp-Ser-Ser-Ser-Ser-
Lys-Ala-Pro-Pro-Pro-Ser-Leu-Pro-Ser-Pro-Ser-
Arg-Leu-Pro-Gly-Pro-Ser-Asp-Thr-Pro-Ile-Leu-
Pro-Gln

For specificity of antibody action it is necessary that distinctive peptides be isolated or prepared that contain molecular structures completely or substantially completely different from the other hormones. The beta subunit of HCG possesses a specific chain or chains of amino acid moieties which differ either completely or essentially from the polypeptide chain of Human Luteinizing Hormone. These chains or fragments, when conjugated with a carrier, represent an additional aspect of this invention. Accordingly, the polypeptide Structures (II) and (III) [C-terminal portions of structure I]

Structure (II)

Asp-Asp-Pro-Arg-Phe-Gln-Asp-Ser-Ser-Ser-Ser-
Lys-Ala-Pro-Pro-Pro-Ser-Leu-Pro-Ser-Pro-Ser-
Arg-Leu-Pro-Gly-Pro-Ser-Asp-Thr-Pro-Ile-Leu-
Pro-Gln

Structure (III)

Gln-Asp-Ser-Ser-Ser-Ser-Lys-Ala-Pro-Pro-Pro-
Ser-Leu-Pro-Ser-Pro-Ser-Arg-Leu-Gly-Pro-Ser-
Asp-Thr-Pro-Ile-Leu-Pro-Gln

whether obtained by purely synthetic methods or by enzymatic degradation from the natural or parent polypeptide, [Carlson et al., J. Biological Chemistry, 284 (19), 6810, (1973)] when modified according to this invention, similarly provide materials with antigenic properties sufficient to provide the desired immunological response.

The beta subunit set forth at structure (I) is seen to represent a chemical sequence of 145 amino acid components. This structure has a high degree of structural homology with the corresponding subunit of Luteinizing Hormone (LH) to the extent of the initial 110 amino acid components. As indicated above, it may be found desirable, therefore to evoke a high specificity to the Chorionic Gonadotropin hormone or an analogous entity through the use of fragments analogous to the C-terminal, 111-145 amino acid sequence of the subunit. Structure (II) above may be observed to represent just that sequence. Structure (III) is slightly shorter, representing the 116-145 amino acid positions within the subunit sequence.

Further polypeptide chains useful in the present antigenic conjugates to promote antibody build-up against natural CG include the following structures labeled Structures (IV)-(XIV). In the present conjugates, these polypeptides provide immunogenic activity against HCG. All of these polypeptides are considered fragments of HCG by virtue of their substantial resemblance to the chemical configuration of the natural hormone and the immunological response provided by them when modified by the instant processes.

Structure (IV)

Cys-Pro-Pro-Pro-Pro-Pro-Pro-Ser-Asp-Thr-Pro-
Ile-Leu-Pro-Gln

Structure (V)

Asp-Asp-Pro-Arg-Phe-Gln-Asp-Ser-Pro-Pro-Pro-
Pro-Pro-Pro-Cys

Structure (VI)

Phe-Gln-Asp-Ser-Ser-Ser-Ser-Lys-Ala-Pro-Pro-

Pro-Ser-Leu-Pro-Ser-Pro-Ser-Arg-Leu-Pro-Gly-
Pro-Ser-Asp-Thr-Pro-Ile-Leu-Pro-Gln

Structure (VII)

Asp-Asp-Pro-Arg-Phe-Gln-Asp-Ser-Ser-Ser-Ser-
Lys-Ala-Pro-Pro-Pro-Ser-Leu-Pro-Ser

Structure (VIII)

Asp-Asp-Pro-Arg-Phe-Gln-Asp-Ser-Pro-Pro-Pro-
Cys-Pro-Pro-Pro-Ser-Asp-Thr-Pro-Ile-Leu-Pro-Gln

Structure (VIIIa)

Asp-Asp-Pro-Arg-Phe-Gln-Asp-Ser-Pro-Pro-Pro-
Pro-Pro-Pro-Cys-Pro-Pro-Pro-Pro-Pro-Pro-Ser-
Asp-Thr-Pro-Ile-Leu-Pro-Gln

Structure (IX)

Asp-His-Pro-Leu-Thr-Ala-Asp-Asp-Pro-Arg-Phe-
Gln-Asp-Ser-Ser-Ser-Ser-Lys-Ala-Pro-Pro-Pro-
Ser-Leu-Pro-Ser-Pro-Ser-Arg-Leu-Pro-Gly-Pro-
Ser-Asp-Thr-Pro-Ile-Leu-Pro-Gln-Pro-Pro-Pro-
Pro-Pro-Pro-Cys

Structure (X)

Asp-Asp-Pro-Arg-Phe-Gln-Asp-Ser-Ser-Ser-Ser-
Lys-Ala-Pro-Pro-Pro-Ser-Leu-Pro-Ser-Pro-Ser-
Arg-Leu-Pro-Gly-Pro-Ser-Asp-Thr-Pro-Ile-Leu-
Pro-Gln-Pro-Pro-Pro-Pro-Pro-Pro-Cys

Structure (XI)

Asp-Asp-Pro-Arg-Phe-Gln-Asp-Ser-Ser-Ser-Ser-
Lys-Ala-Pro-Pro-Pro-Ser-Leu-Pro-Ser-Pro-Ser-
Arg-Leu-Pro-Gly-Pro-Ser-Asp-Thr-Pro-Ile-Leu-
Pro-Gln-Cys

Structure (IV) will be recognized as incorporating a Cys component at the amino or N-terminal which is associated with a proline spacer sequence. These spacers serve to position the sequence which follows physically distant from the carrier-modifier. The latter sequence may be observed to present the 138th to 145th amino acid sequence of the subunit Structure (I). Structure (V) on the other hand, represents an initial sequence corresponding with the 111th to 118th amino acid sequence of the subunit Structure (I) followed by a sequence of six proline spacer components and a carboxyl terminal, present as cysteine. The rationale in providing such a spacer component is to eliminate sites which may remain antigenically neutral in performance. Structures (IV) and (V) represent relatively shorter amino acid sequences to the extent that each serves to develop one determinant site. Consequently, as alluded to in more detail hereinafter, they are utilized in conjunction with a mixed immunization technique wherein a necessary two distinct determinants are provided by the simultaneous administration of two such fragments, each conjugated separately. Structure (VI) represents the 115th through 145th component sequence of structure (I). Structure (VII) represents a portion of Structure (I); however, essentially, a sequence of the 111th to 130th components thereof is formed.

Structure (VIII) incorporates two sequences, one which may be recognized in Structure (V) and the other in Structure (IV). These two sequences are separated by two spacer sequences of proline components and one is joined with an intermediately disposed cysteine component which serves a conjugation function. With this arrangement, two distinct determinant sites are developed in physically spaced relationship to avoid the development of an unwanted artificial determinant possibly otherwise evolved in the vicinity of their mutual coupling. Structure (VIIIa)

represents Structure (VIII) with additional proline spacer residues to provide a widened spacing of determinant sites.

Structure (IX) mimics sequences from Structure (I) with the addition of a proline spacer sequence, a cysteine component at the C-terminal, and an Aba substituted for cysteine at the 110 position. The Aba designation is intended herein to mean alpha aminobutyric acid of Cysteine. Structure (X) will be recognized as a combination of Structure (II) with a six residue proline spacer sequence and a cysteine component at the C-terminal. Similarly, Structure (XI) combines Structure (II) with a cysteine component at the C-terminal without a proline spacer sequence.

Other useful peptides include:

Structure (XII)

Thr-Cys-Asp-Asp-Pro-Arg-Phe-Gln-Asp-Ser-Ser-
Ser-Ser-Lys-Ala-Pro-Pro-Pro-Ser-Leu-Pro-Ser-
Pro-Ser-Arg-Leu-Pro-Gly-Pro-Ser-Asp-Thr-Pro-
Ile-Leu-Pro-Gln

Structure (XIII)

Asp-His-Pro-Leu-Thr-Aba-Asp-Asp-Pro-Arg-Phe-
Gln-Asp-Ser-Ser-Ser-Ser-Lys-Ala-Pro-Pro-Pro-
Ser-Leu-Pro-Ser-Pro-Ser-Arg-Leu-Pro-Gly-Pro-
Ser-Asp-Thr-Pro-Ile-Leu-Pro-Gln-Cys

Structure (XIV)

Cys-Pro-Pro-Pro-Pro-Pro-Pro-Pro-Asp-Asp-Pro-
Arg-Phe-Gln-Asp-Ser-Ser-Ser-Ser-Lys-Ala-Pro-
Pro-Pro-Ser-Leu-Pro-Ser-Pro-Ser-Arg-Leu-Pro-
Gly-Pro-Ser-Asp-Thr-Pro-Ile-Leu-Pro-Gln

Structure (XII) will be recognized as having the sequence of Structure (II) with the addition of Thr-Cys residues at its N-terminal. Structure (XIII) is similar to Structure (IX) but does not contain the spacer sequence. Structure (XIV)

will be recognized as being similar to Structure (II) with the addition of spacer components at the N-terminal and a cysteine residue, which may be useful for modification reactions, as described in more detail below.

As already mentioned, it is only the 111-145 amino acid sequence of beta-HCG which differs from the corresponding sequence of LH. However, research indicates that the peptides used in the present conjugates may contain sequences corresponding to the 101-110 sequence which is common to beta-HCG and beta-LH without inducing the formation of antibodies reactive to LH. Thus, one can use in the instant conjugates peptides containing part or all of the common 101-110 sequence without causing substantial cross-reactivity with LH. For example, Structure (II) above represents the 111-145 amino acid sequence of beta-HCG. If desired, therefore, a peptide having the 101-145 amino acid of beta-HCG could be substituted for the peptide of Structure (II) in the instant conjugates without substantially affecting the activity of the modified polypeptide and without causing cross-reactivity with beta-LH. As already mentioned, a peptide corresponding to the 109-145 sequence of beta-HCG is especially useful in the present vaccines and conjugates.

For reasons already noted, the need to avoid cross-reactivity with luteinizing hormone mainly restricts the chorionic gonadotropin-derived peptides used in the vaccines and conjugates of the present invention to peptides containing all or part of the 101-145 sequence of chorionic gonadotropin, since it is only this part of the chorionic gonadotropin sequence which differs significantly from luteinizing hormone. However, it has been found that there are antigenic determinants on the human chorionic gonadotropin molecule that will produce human chorionic gonadotropin-specific antibodies, which antigenic determinants are not located on the 101-145 sequence of human chorionic gonadotropin. One such antigenic determinant is the sequence corresponding to the sequence 40-52, or the sequence 38-57, of the beta-subunit of human chorionic gonadotropin. Thus, peptides comprising an amino acid sequence substantially similar to the 38-57 region (or part of this region) of the

beta-subunit of human chorionic gonadotropin can be used in the vaccines and conjugates of the present invention.

The beta-HCG(38-57) peptides are, however used in a manner rather different from the beta-HCG(101-145) peptides previously discussed. Since the 38-57 region of the beta-subunit of human chorionic gonadotropin is substantially similar to the corresponding region of human luteinizing hormone, follicle stimulating hormone and thyroid stimulating hormone (and the same is true in other species), it is not advisable to use the beta-HCG(38-57) peptides alone in the vaccines and conjugates of the invention, since this involves a substantial risk of producing antibodies with an undesirable degree of cross-reactivity with other hormones. However, as noted above, it is advantageous for the vaccines and conjugates of the invention to comprise more than one antigenic determinant of the target protein, since this increases the efficacy of the vaccine or conjugate in raising antibodies, and thus produces a higher antibody titer in the treated animal. Accordingly, it is highly desirable that the beta-HCG(38-57) and analogous peptides be used in the vaccines and conjugates in conjunction with a peptide which is more specific to human chorionic gonadotropin, in order that the vaccine or conjugate will be highly efficacious in raising antibodies, but will still be sufficiently specific that an undesirable level of cross-reaction is not experienced. In particular, it is recommended that the beta-HCG(38-57) peptide be used in conjunction with a peptide derived from, or similar to, the 109-145 sequence (or, for the reasons discussed above, the 101-145 sequence) of the same hormone subunit.

The joint use of the 38-57 and 101-145 peptides may be achieved in three separate ways. Firstly, the betaHCG(38-57) peptide may further comprise one or more amino acid sequences substantially similar to at least part of the 101-145 region of the same hormone subunit; i.e., the two sequences may be chemically combined in the same peptide prior to modification of the peptide. Secondly, both peptides may be chemically linked to the same carrier without first being chemically bonded to one another. Finally, the two peptides may be bonded to separate carriers

and a mixture of the two resultant conjugates introduced into the animal to be treated.

Such polypeptides may comprise the 38-57 region of the beta-subunit of human chorionic gonadotropin, or the analogous sequence of other mammalian chorionic gonadotropins, depending of course upon the mammal in which the resultant conjugate is to be used. This 38-57 sequence may be used alone, or the sequence may include adjacent regions substantially similar to the adjacent regions of the beta-subunit of the appropriate chorionic gonadotropin, even though the presence of such adjacent regions is not necessary to produce proper antigenic properties in the conjugate. For practical reasons such as the difficulty of synthesizing very long peptides, and cost, it is desirable that the peptide having the amino acid sequence comprised of the 40-52 region, and corresponding to the 38-57 region, of the beta-subunit not contain more than about 40 amino acid residues.

Although sufficient for provoking antigenic activity, the simple amino acid sequence corresponding to the 38-57 region of HCG does have the disadvantage that it does not possess any convenient site at which coupling of the peptide to a carrier, or to other fragments used in the synthesis of the vaccines and conjugates of the invention can be effected. Accordingly, in order to provide the peptide with a convenient coupling site, it is preferred that the peptide have attached, to the portion of the amino acid sequence corresponding to residue 38 of the beta-subunit of human chorionic gonadotropin, a spacer sequence of amino acid residues not substantially similar to the 30-37 region of the beta subunit of human chorionic gonadotropin, and further that the peptide have attached, to the N-terminal of this spacer sequence, a reactive residue suitable for coupling the peptide to a carrier, or to another peptide fragment in the conjugate of the invention. Preferably, the spacer sequence comprises a plurality (conveniently 6) of proline residues and the reactive residue comprises an alanine residue.

Alternatively, in order that the 38-57 peptide can be used in certain preferred coupling reactions (discussed below) which require the presence of a free sulfhydryl group on the peptide, one might add to one terminal (preferably the

N-terminal) of the 38-57 peptide a cysteine residue. However, if such an additional cysteine residue is added to the 38-57 peptide, care must be taken to ensure that, during the necessary cyclization of the peptide, the correct cysteine residues become linked by the disulfide bridge. This is conveniently effected by placing a blocking group on the "extra" cysteine residue before it is incorporated into the peptide and removing the blocking group only after the disulfide bridge has been formed. Appropriate blocking groups are well-known to those skilled in the art and some are discussed below.

As used in the modified vaccines and conjugates of the invention, the peptide comprising an amino acid sequence corresponding to the 38-57 region of the beta subunit of HCG is used in a form in which the two cysteine residues corresponding to the cysteine residues at positions 38 and 57 of the beta-subunit of HCG have their sulfur atoms linked in a disulfide bridge, since it appears to be only this form of the peptide, in which in effect the disulfide bridge close a loop, which has strongly antigenic properties <u>in vivo</u>. In the present state of chemical synthesis, it is in practice necessary to cyclize the 38-57 peptide before coupling it to a carrier (or to other peptide fragments) since the conditions necessary for cyclization cannot readily be produced after the peptide is coupled to a carrier (or to other peptide fragments).

As with other peptides mimicking fragments of endogenous protein hormones, the peptide corresponding to the 38-57 range of the beta-subunit of HCG need not have an amino acid sequence identical to that occurring in the natural beta-subunit, provided that there is a sufficient degree of immunological similarity between the amino acid sequence of the peptide and that in the natural beta-subunit i.e. provided the peptide, when modified to form a vaccine or conjugate according to the invention, provides sufficient antigenic activity to provoke antibodies having good reactivity with, and selectivity for, the natural HCG. Certain amino acid substitutions which can be made without substantially reducing the immunological similarity between the artificial peptide and the natural sequence of the beta-subunit of HCG will be well known to those skilled in the art, and the degree of

immunological similarity of any proposed amino acid sequence can of course be determined by routine empirical tests.

Not only do chorionic gonadotropins derived from other mammalian species have a region highly analogous to the 38-57 sequence of human chorionic gonadotropin, but a closely analogous region exists in other mammalian glycoprotein hormones including luteinizing hormone, follicle stimulating hormone and thyroid stimulating hormone. Consequently, peptides derived from the regions of non-human chorionic gonadotropin and other mammalian glycoprotein hormones having an analogous region may also be used in preparing the vaccines and conjugates of the present invention. The regions of several specific mammalian glycoproteins analogous to the 38-57 region of HCG are given in detail below, but those skilled in the art will have no difficulty in identifying an analogous region in other specific mammalian glycoproteins. As previously noted, peptides having sequences similar, but not identical, to the natural sequence may also be used provided they are substantially immunologically equivalent to the natural sequence.

Examples of specific preferred peptides having sequences analogous to the 38-57 region of HCG and useful in the vaccines and conjugates of the present invention are as follows:

(Structure XXV)

Cys-Pro-Ser-Met-Lys-Arg-Val-Leu-Pro-Val-Ile-Leu-
Pro-Pro-Met-Pro-Gln-Arg-Val-Cys;

(Structure XXVI)

Cys-Pro-Thr-Met-Met-Arg-Val-Leu-Gln-Ala-Val-Leu-
Pro-Pro-Leu-Pro-Gln-Val-Val-Cys;

(Structure XXVII)

Cys-Pro-Thr-Met-Thr-Arg-Val-Leu-Gln-Gly-Val-Leu-
Pro-Ala-Leu-Pro-Gln-Val-Val-Cys;

(Structure XXVIII)
Cys-Tyr-Thr-Arg-Asp-Leu-Val-Tyr-Lys-Asn-Pro-Ala-
Arg-Pro-Lys-Ile-Gln-Lys-Thr-Cys;

(Structure XXIX)
Cys-Tyr-Thr-Arg-Asp-Leu-Val-Tyr-Lys-Asp-Pro-Ala-
Arg-Pro-Lys-Ile-Gln-Lys-Thr-Cys;

(Structure XXX)
Cys-Pro-Ser-Met-Val-Arg-Val-Thr-Pro-Ala-Ala-Leu-
Pro-Ala-Ile-Pro-Gln-Pro-Val-Cys;

(Structure XXXI)
Cys-Met-Thr-Arg-Asp-Ile-Asp-Gly-Lys-Leu-Phe-Leu-
Pro-(Lys-Tyr)-Ala-Leu-Ser-Gln-Asp-Val-Cys.

Structure XXVII is the 38-57 region of human chorionic gonadotropin. Structure XXX is the corresponding sequence from equine chorionic gonadotropin. Structure XXVI is the corresponding region of human luteinizing hormone, and Structure XXV is the corresponding region of ovine/bovine luteinizing hormone. Structure XXVIII is the corresponding region of human follicle stimulating hormone, while Structure XXIX is the corresponding region of equine follicle stimulating hormone. Structure XXXI is the corresponding region of thyroid stimulating hormone. The (Lys-Tyr) portion of this hormone sequence is in parentheses because it represents an "insert" between positions 50 and 51 of the corresponding HCG sequence, and thus has no direct equivalent in any of the other sequences given above.

It should be noted that there are some differences of opinion among those skilled in the field of protein sequence determination as to certain minor details of the above sequences. See, for example:

Pierce and Parsons, Ann. Rev. Biochem. 50: 469-95 (1981).

In particular, some authorities dispute the existence of the aforementioned (Lys-Tyr) insert in the human thyroid stimulating hormone sequence, while other authorities dispute the existence of the methionine at position 42 and the valine at position 55 of the human luteinizing hormone sequence. However, for reasons discussed above, even if the natural sequences do differ from those just given, the sequences just given are certainly sufficiently close to the natural sequences to produce a strong antigenic reaction when incorporated into vaccines and conjugates of the invention.

Relaxin

Another group of peptides which can be used in the present vaccines and conjugates are relaxin and polypeptides derived therefrom. It has been known for a long time that relaxin is a peptide hormone synthesized in the corpus luteum of ovaries during pregnancy and the hormone is released into the bloodstream prior to parturition. The major biological effect of relaxin is to remodel the mammalian reproductive tract to facilitate the birth process, primarily by relaxing the cervix, thereby assisting in the dilation of the cervix prior to parturition. The amino acid sequence, which bears some resemblance to that of insulin, has been determined; see:

Hudson et al, Structure of a Genomic Clone Encoding Biologically Active Human Relaxin.

This paper also gives methods for the synthesis of certain relaxin-derived peptides.

The use of relaxin or peptides derived therefrom in the present vaccines and conjugates depends not upon the natural function of relaxin during parturition, but upon the fact that anti-relaxin antibodies are known to render sperm immotile. Thus, there appears to be a relaxin-like antigen present on the surface of sperm, especially since the immotility of the sperm can be reversed by adding relaxin to the antibody/sperm complex. In theory one could use modified sperm antigens to generate in the male antibodies to various antigens present in sperm, but there is the serious problem that, owing to the blood/testes barrier, such anti-sperm antibodies do not penetrate the testes. The potentially very rapid induction of immotility of anti-relaxin antibody renders generation of such an antibody in males a highly

attractive potential form of male contraception. Although the anti-relaxin antibodies will not penetrate the testes because of the blood/testes barrier, they can penetrate the epididymis and they will also be secreted into the fluid which becomes mixed with the sperm shortly before or during ejaculation. Thus, by producing anti-relaxin antibodies in the male, ejaculation would take place normally but the sperm produced would be immotile. Furthermore, the risk of complications and unintended tissue damage by such an instant process is slight, since the antibodies will not enter the testes, thereby avoiding potentially damaging reactions due to antibody-antigen binding within the testes.

It should be noted that injection of relaxin-derived conjugates of the present invention into females is not recommended; such a process would carry too great a risk of ovarian damage in the female.

It should also be noted that relaxin is a highly species-specific protein. Accordingly, when choosing an appropriate peptide derived from relaxin, care should be taken to ensure that the peptide corresponds to part of the sequence of human relaxin (or, of course, relaxin of any other species which it is designed to treat).

Cancer Treatment

Another health problem that can be treated by the instant methods is that of certain endocrine or hormone-dependent tumors or cancers. Certain breast cancers have been shown to be dependent upon the abundant secretion of the hormone prolactin for their continued survival. The inhibition of the secretion of prolactin has been shown to diminish the growth rate and the actual survival of certain of these tumors. The immunization of mammals suffering from such tumors with conjugates related to prolactin would result in the systematic reduction of the level of prolactin circulating in the system and consequently may result in the regression or remission of tumor growth. The consequence of this treatment would be far more favorable in terms of effective treatment of this disease, since surgical removal of the breast is the principal method of treatment currently available. It is of course likely that the vaccines and conjugates of the present invention will be

effective only against those tumors which are dependent upon the secretion of prolactin (or some other hormone) for survival.

Investigators have also determined, for example, that certain polypeptide entities are supportive factors to, and secretions of, neoplastic diseases in both man and other mammals. These supportive entities have biochemically, biologically and immunologically close resemblances to hormones, particularly to CG as well as to LH. Using the vaccines and conjugates of the instant invention the function of such polypeptides or endogenous counterparts can be neutralized to carry out regulation of the malignancy. For example, tumors in both male and female primates may be treated by isoimmunization procedures developing antibodies to CG or LH or the disease supportive factors analogous thereto. Furthermore, neoplasms in primate females may be regulated by isoimmunization procedures developing antibodies to endogenous LH. This hormone, when associated with a tumor state, tends to aggravate the tumorous condition.

It appears that certain carcinomas exude CG or an immunologically-similar material on their surfaces, thereby presenting to the immune system of the host animal a surface which, superficially, appears to be formed of material endogenous to the host animal and which is thus relatively non-immunogenic. Because of this known association between certain carcinomas and CG or CG-like materials, the CG-derived conjugates of the invention are useful not only for fertility control but also for treatment of carcinomas associated with CG or CG-like materials. As already mentioned, vaccines and conjugates of the invention are useful for the treatment of a variety of malignant diseases, including breast cancer, lung cancer, colon cancer, malignant melanoma and bladder carcinoma.

<u>Techniques for modification of Hormones, Fragments or Peptides</u>

A wide range of techniques may be used to form the conjugates used in the present vaccines. Many of the techniques described below are not in themselves novel and some of the techniques may be found in the following list of literature references, while various others may be found elsewhere in literature by persons skilled in the art:

1. Klotz et al., Arch. of Biochem. and Biophys, 96,60 605-612, (1966).

2. Khorana, Chem. Rev. S3 145 (1953).

3. Sela et al., Biochem. J., 85, 223 (1962).

4. Eisen et al., J. Am. Chem. Soc., 75, 4583 (1953).

5. Centeno et al., Fed. Proc. (ABSTR), 25, 729 (1966).

6. Sokolowsky et al., J. Am. Chem. Soc., 86, 1212 (1964).

7. Tabachnick et al., J. Biol. Chem., 234, 1726, (1959).

8. Crampon et al., Proc. Soc. Exper. Biol. & Med., 80, 448 (1952).

9. Goodfriend et al., Science, 144, 1344 (1964).

10. Sela et al., J. Am. Chem. Soc., 78, 746 (1955).

11. Cinader et al., Brit. J. Exp. Pathol., 36, 515 (1955).

12. Phillips et al, J. of Biol. Chem., 240(2), 699-704 (1965).

13. Bahl, J. of Biol. Chem., 244, 575 (1969).

It will be appreciated by those skilled in the art that, in the instant invention, the chemical modification of the hormone, fragment or peptide is effected outside the body of the animal prior to introduction of the conjugate into the body of the animal.

Conjugation of hormones, fragments or peptides to chemically-modified diphtheria toxoid or T cell epitopes to form the vaccines and conjugates of the present invention may be effected by attaching to the hormone, fragment or peptide one or more foreign reactive (modifying) groups and/or by attaching two or more fragment peptides to a single foreign reactive group (i.e. a carrier) or both of the above, so that the body of the animal, recognizing the conjugate as a foreign object, produces antibodies which complex with not only the conjugate but also the unmodified hormone responsible for the disease or medical problem being regulated.

Particularly where the larger whole hormone or subunit type molecular structures are concerned, the number of foreign reactive groups which are to be attached to the hormone or subunit and the number of hormone or subunits to be attached to a foreign reactive group depends on the specific problem being treated.

Basically, what is required is that the conjugate be modified to a degree sufficient to cause it to be antigenic when injected into the body of the animal. If too little modification is effected, the body may not recognize the conjugate as a foreign body and not create antibodies against it. If the number of foreign molecules added is too great, the body will create antibodies against the conjugate, but the antibodies will be specific to the conjugate and will not neutralize the action of the concerned natural endogenous hormone, i.e. they will be specific to the modifier.

In general, again considering the larger molecule subunit or whole hormone, it has been found that about 1-40 modifying groups per molecule of hormone or subunit will be useful in modifying the polypeptide adequately so as to obtain the desired immunological effect of this invention. As will be appreciated by one skilled in the art, this ratio of modifying groups will vary depending upon whether an entire hormone is utilized for modification or whether for instance a relatively small synthetic fragment of the hormone is to be modified. Generally for the larger molecules, it is preferred that 2-40 modifying groups per molecule of polypeptide be used according to this invention. In the instance where the polypeptide is the beta-subunit of HCG, it is particularly preferred that about 5-30 and more preferably 10-26 modifying groups per molecule of polypeptide be used. The degree of modification of the polypeptide should be adequate to induce generation, by the animal, of antibodies adequate to neutralize some of the target hormone or non-hormonal protein. The necessary degree of modification will vary with each polypeptide involved, and the degree of correction or change desired for the body function involved. As already noted, in the present vaccines, it is preferred that the conjugate comprise 20-30 peptides per 10^5 daltons of the chemically-modified diphtheria toxoid.

It is preferred that the modification constitute two or more immunological determinants represented on the native protein to which it is desired to evoke an antibody response. The effect is one of heterogeneity of antibody development. Thus, several peptides have been described above having at least two distinct amino acid sequences represented in the HCG beta subunit. These sequences

may be so spaced as to present the determinants in mutual isolation, while the spaced sequence fragment is conjugated with the carrier. Alternately, a mixed immunization arrangement may be utilized wherein a first peptide fragment developing one determinant is conjugated with a first carrier molecule and is administered in combination with a second, distinct peptide fragment which is conjugated with a second carrier molecule, the latter of which may be the same as or different in structure from the first carrier. Thus, each macromolecular carrier may be conjugated with hormone fragments such that each fragment represents two or more immunological determinants.

In one preferred modification process, the hormone, fragment or peptide to be modified, for example that designated Structure (XII) above, is activated first, after which it is conjugated with the carrier (chemically modified diphtheria toxoid or T cell epitope). An activating reagent may be utilized which exhibits differing functionality at its ends and, by choice of reaction conditions, these end functions can be made to react selectively. For example, the activators of Formulae A and B shown in Figure 1 of the accompanying drawings, which each have a maleiimido group and a substituted acid group, may be used. In these activators, X is a non-reacting group which can be a substituted or unsubstituted phenyl or C1-C10 alkylene moiety, or a combination thereof. The substituent on the phenyl ring (if any) should of course be non-interfering with the reactions of the activator, as should the remainder of the grouping X.

The grouping X may be, inter alia, a pentamethylene, 1,4-phenylene or monomethyl-1,4-phenylene grouping.

The maleiimido grouping of the above activators will react with sulfhydryl (SH) groups in the hormone, fragment or peptide to be modified under conditions whereby the opposite end (active ester end) of the reagent does not react with the amino groups present in the hormone, fragment or peptide. Thus, for example, peptides, such as that designated Structure (XII) above, contain a cysteine amino acid, and hence an SH group, react as shown in Reaction 1 in Figure 2 of the accompanying drawings. Following the above reaction, upon adjusting the pH to

slightly alkaline condition, for example, pH 8, and adding the carrier, conjugation is accomplished to produce the product of Formula 2 shown in Figure 2.

A carrier which does not contain SH groups, but does contain NH_2 groups, is preferably first treated with an activator of the formula A or B shown in Figure 1, wherein X is as defined above, at pH 7 or lower to cause reaction of the active ester end of the activator with the carrier, giving a compound of Formula 3 shown in Figure 2. Thereafter, the activated carrier is reacted with a hormone, fragment or peptide containing a SH group to produce a conjugate similar to that discussed immediately above.

Should the hormone, fragment or peptide not contain an SH group, e.g. Structures (II), (III), (VI) and (VII), such structures can be modified first to introduce such a grouping by standard methods such as "thiolactonization", following which they are conjugated utilizing the above-discussed selective bi-functional reagents. For a more detailed description of these reagents, reference is made to the following publications:

O. Keller and J. Ridinger, Helv. Chim. Acta, 58, 531-541 (1975).

W. Trommer, H. Kolkenbrock and G. Pfleiderer, Hoppe-Seyler's Z. Physiol. Chem., 356, 1455-1458 (1975).

As already mentioned, in many natural proteins containing cysteine residues, these residues are not present in the thiol form containing a free SH group; instead, pairs of cysteine residues are linked by means of disulfide bridges to form cysteine. Accordingly, when it is desired to produce free SH groups in proteins to carry out the coupling reactions discussed above, one convenient way of providing such free SH groups may be to cleave disulfide bridges naturally present in the protein or other polypeptides which it is desired to conjugate. For example, as noted above the natural form of beta-HCG contains six disulfide bridges. To produce free thiol groups for coupling reactions, any number of these bridges from 1 to 6 may be broken using known techniques as set out for example in:

Bahl et al, Biochem. Biophys. Res. Comm., 70, 525-532 (1976).

This particular article describes cleavage of 3-5 of the six disulfide bridges in beta-HCG, but the same techniques may be used to break all six bridges if this is so desired. It should, however, be noted that the techniques disclosed in this paper are not selective and although it is possible to control the degree of disulfide bridge breaking, it is not possible to break specific bridges and leave others. The breaking of bridges is at random and the thiol groups produced are randomly distributed over the possible positions in beta-HCG.

As an alternative approach to the utilization of the maleiimido group reagents discussed above, an alkylation step may be used to cause conjugation. Conditions can be chosen such that, in the presence of amino groups, essentially only thiol groups will be alkylated. With this approach, the larger carrier molecule is first modified by reaction of a fraction of its amino groups with an active ester of chloro, dichloro, bromo, or iodo acetic acid such as the compound of Formula C shown in Figure 1. This modified carrier is then reacted with the sulfhydryl group in the hormone, fragment or peptide to be modified (or a modified form of the polypeptide which has already been modified to contain a free thiol group (e.g. by the thiolactonization which is discussed above) if it did not originally posses such a free thiol group). The reaction produces a thioether linkage by alkylation of the free-thiol (sulfhydryl) group.

It may be seen from an observation of the formulae of Structures (IV), (V), (IX), (X), (XI), (XII), (XIII), and (XIV) that a Cys amino acid, which in a reduced state provides an SH reactive group, is located at either the C-terminal or N-terminal of the peptide structure. This location permits the peptide to be chemically linked to carrier molecules at either terminus. Moreover, the Structures (XIV), (X), (IX), (X), (IV) have a six-proline spacer chain (Pro)6 between the cysteine residue and the remainder of the peptide sequence. This latter arrangement provides a chemical spacer between the coupled carrier and the sequences representing a fragment of the natural hormone. A six-proline spacer can be added as a side chain spacer, for example at position 122 (lysine) in Structure (II), by initially adding an SH group (thiolactonization) to the free or unblocked epsilon

amino group on this (lysine) residue. As previously noted, if such a spacer is employed, it desirably comprises from 2 to 8 amino acid residues. Then, utilizing the activator A or B in Figure 1 in which the component "X" is a chain of six proline amino acids, conjugation can be carried out. In the latter case, a spacer is provided between the carrier and peptide linked at an intermediate site, for example at position 122 in Structure (II). In the former case, only the spacer derived from the conjugating reagent links the carrier and peptide.

Carriers containing free amino groups can be prepared in buffer solution, such as phosphate buffer, in sodium chloride solution at a pH of 6-8. To this solution, tolylene diisocyanate (T.D.I.C.) reagent diluted from about 1-10 to about 1-40 times with dioxane can be added to the carrier. The general procedure was disclosed by Singer and Schick, J. Biophysical and Biochem. Cytology, 9, 519 (1961). The amount of T.D.I.C. added may range from 0.075 to 1,000 molar equivalents of the carrier used. The reaction may be carried out at about - 5° to about + 10°C., preferably 0° to 4° C, for about 1/2 to 2 hours. Any excess T.D.I.C. may be removed by centrifugation. The precipitate may be washed with the above-mentioned phosphate buffer and the supernatants combined.

This activated carrier solution may then be combined with the hormone, fragment or peptide to be conjugated. The hormone, fragment or peptide is dissolved in the same phosphate buffer (5-30 mg/ml) and the volumes of the two solution needed to provide the desired molar ratio of carrier to hormone, fragment or peptide in the conjugate are combined. The combined solutions are desirably reacted at 30°-50°C, preferably 35°-40°C, for 3-6 hours.

Separation of modified and unmodified hormone, fragment or peptide may be accomplished by conventional techniques, such as gel filtration.

Picogram amounts of I^{125} labeled polypeptide may be added as a tracer to the reaction mixture at the time of conjugation, and the quantity of hormone, fragment or peptide conjugated to carrier (molar ratio) may be determined by the amount of radioactivity recovered.

Included in the methods for modifying the hormones, fragments and peptides are conjugation by use of water-soluble carbodiimide. The amino groups of the unmodified hormone, fragment or peptide are first preferably protected by acetylation. This (acetylated) unmodified hormone, fragment or peptide is then conjugated to the carrier using 10-ethyl-3-(3-dimethylamino propyl)carbodiimide as activating agent. This method is generally disclosed by Hoare and Koshland, Jr., J. of Biological Chemistry, 242, 2447 (1967). The conjugation between the unmodified hormone, fragment or peptide and the carrier may be performed in a solvent such as glycine methyl ester while maintaining the pH at about 4-5, preferably about 4.5-4.8. The temperature of reaction is conveniently about room temperature and the reaction may be allowed to proceed for about 2-8 hours, preferably 5 hours. The resulting conjugate may be purified by conventional techniques, such as column chromatography.

Conjugates may also be prepared using glutaric dialdehyde as conjugating agent. According to a theory proposed by Richards and Knowles [J. Mol. Biol., 37, 231 (1968)], commercial glutaric dialdehyde contains virtually no free glutaric dialdehyde, but rather consists of a very complex mixture of polymers rich in alpha, beta-unsaturated aldehydes. Upon reaction with amino acid carriers, these polymers form a stable bond through the free amino group, leaving aldehyde groups free. This intermediate product then reacts with unmodified hormone, fragment or peptide in the presence of alkali metal borohydride, such as sodium borohydride. This intermediate is formed at pH 7-10, preferably 8-9, at about room temperature. The modified hormone, fragment or peptide is also conveniently obtained at about room temperature after about 1/4 -2 hours reaction time. The resulting product is recovered in pure form by conventional techniques, such as gel filtration, dialysis and lyophilization.

Throughout the foregoing description, the term "modified" or "conjugated" has been utilized in referring to the chemical reaction by which the carrier molecules become chemically attached to specific sites on the hormone, fragment or peptide. Although specific mechanisms by which this is accomplished

are described herein in detail, other appropriate mechanisms may be used if desired. It is clear that the carrier can be a physically larger molecule or fragment thereof than the hormone, fragment or peptide which it modifies. Clearly, physical size of the carrier is not always critical (many of the T cell epitopes used in the conjugates of the present invention only contain about 15 to 20 amino acid residues), the criterion for effectiveness being that the mammalian body's reaction generate antibodies in sufficient quanta and specificity to the target hormone.

Vaccines/Administration of the Conjugates

Obviously, in order that the conjugates of the invention can provoke the formation of antibodies to the target hormone within the body of an animal, they must be administered to the animal in such a way that they can come into contact with the cells responsible for formation of antibodies. In practice, this essentially means that the conjugates must be introduced into the circulatory system of the mammal to which they are administered. Although the use of other modes of administration is not absolutely excluded, in view of the molecular size and weight of most of the instant conjugates likely to be used in practice, the normal route or administration will be parental administration i.e. by injection. In the vast majority of cases, the quantity of conjugate which will need to be administered will be far too small for convenient handling alone, and in any case the chemical nature of most of the conjugates prevents them being produced in a pure form free from liquid vehicles. Accordingly, it is normally necessary to administer the conjugates of the invention as a vaccine comprising the conjugate together with a vehicle; this vaccine is desirably a vaccine of the present invention in which the conjugate and an adjuvant are dispersed in a phosphate-buffered saline aqueous vehicle, which is then emulsified with a mixture of oils, preferably a mixture of squalene and squalane oils, and mannide monooleate. It has been found that administration of the conjugate in such a vaccine has the effect of increasing the quantity of antibodies provoked by the conjugate when the vaccine is administered to an animal. To further increase the quantity of antibodies provoked by administration of the vaccine, it is advantageous to include in the vaccine an immunological adjuvant. The term "adjuvant" is used

in its normal meaning to one skilled in the art of immunology, namely as meaning a substance which will elevate the total immune response of the animal to which the vaccine is administered i.e. the adjuvant is a non-specific immunostimulator. As already mentioned , the preferred adjuvant is N-acetyl-D-glucosamine-3-yl-acetyl-L-ala-D-isoglutamine (nor muramyl dipeptide), although other adjuvants, especially other muramyl dipeptides, for example:

NAc-nor Mur-L.Ala-D.isoGln

NAc-Mur-(6-0-stearoyl)-L.Ala-D.isoGln or

NGlycol-Mur-L.alphaAbu-D.isoGln

may be used if desired.

The vaccines and conjugates of this invention may be administered parenterally to the animals to be protected, the usual modes of administration of the vaccine being intramuscular and sub-cutaneous injections. The quantity of vaccine to be employed will of course vary depending upon various factors, including the condition being treated and its severity. However, in general, unit doses of 0.1-50 mg. in large mammals administered from one to five times at intervals of 1 to 5 weeks provide satisfactory results. Primary immunization may also be followed by "booster" immunization at 1 to 12 month intervals.

Other useful administration methods for the conjugates of the invention include those wherein the conjugate itself, or a solution or an emulsion thereof, is encased in a pharmaceutically acceptable polymer composition, such as in microcapsule form. The microencapsulated conjugate is then administered, for example, by implantation under the skin or intramuscular injection, so as to permit a controlled and/or prolonged and/or timed release of the conjugate. This release of the conjugate in turn elicits a controlled, prolonged, timed or as desired, raising of useful antibodies for purposes described herein. Illustrative of useful polymer compositions for the encapsulation include pharmaceutically acceptable polylactic-polyglycolic acid copolymers known in the art for pharmaceutical microencapsulation.

The following Examples are now given, though by way of illustration only, to show details of particularly preferred reagents, conditions and techniques used in the present invention.

Example 1

This Example illustrates the preparation of a preferred vaccine of the present invention.

Preparation of peptide

Beta-HCG(109-145) was synthesized by solid phase synthesis, as described in the aforementioned U.S. Patents Nos. 4,855,285 and 5,006,334. It should be noted that only a peptide containing a free thiol group can be conjugated to the toxoid, and accordingly it is advisable to determine the thiol content of the peptide quantitatively by Elman's method before conjugating. If necessary, either N-acetyl homocysteine thiolactone or N-succinimidyl-3-(2-pyridylthio)propionate may be used to provide free thiol groups on the peptide.

Preparation of modified diphtheria toxoid

Diphtheria toxoid, of the type used commercially to prepare diphtheria-pertussis-tetanus vaccines, was obtained from a commercial source. The toxoid was obtained in liquid form having an activity of 1000-1500 Lf/ml, and containing 1/5000 thimerosal as preservative. To this toxoid, ethylenediamine (0.1 M) was added at a ratio of 2 mL per 100 mL of the liquid toxoid, and the resultant mixture was concentrated approximately ten-fold by ultrafiltration. The concentrate was gel filtered using either Sephadex G-50 or Biogel P-60 in 0.2 M ammonium bicarbonate. The non-retarded volume was collected and lyophilized.

To determine the amino content of the modified toxoid, the fluorescamine method was used. A small volume of sample solution containing approximately 1.0 mg/mL of modified toxoid was prepared, and a 20 μL aliquot assayed against a standard curve of α-N-acetyl-L-lysine samples containing from 10^{-9} to 10^{-8} moles.

Coupling of peptide to toxoid

Since the maleimido group is light sensitive, the steps of the following preparation using this group are desirably conducted in darkness or subdued lighting.

To prepare an antigenic conjugate comprising approximately 25 peptides per 10^5 daltons of toxoid, 20 mg of the chemically-modified toxoid prepared above was dissolved in 1 mL of 0.5 M aqueous sodium phosphate buffer, pH 6.6. Separately, 6.18 mg of 6-maleimido caproic acyl succinyl ester (MCS) was dissolved in 100 µL of purified, dried dimethylformamide (DMF). 25 µL of the resultant DMF solution was added over a period of 15 minutes to the stirred toxoid solution at room temperature. After the addition was complete, the resultant solution was stirred for a further 75 minutes, and the excess MCS and reaction by-products were removed by gel filtration on Sephadex G-25 equilibrated with 0.1 M sodium citrate/0.1 M EDTA, pH 6.0, at 0-4°C. The activated toxoid excluded from the column was concentrated to approximately 20 mg/mL by ultrafiltration on P10 membrane.

To effect the conjugation of the peptide to the modified toxoid, the solution of the modified toxoid prepared above was added to a solution of the peptide in the same sodium citrate/EDTA, pH 6.0 buffer, and the resultant mixture is stirred under a stream of nitrogen, while sealed from light, for 18 hours at room temperature. The solution was then passed through a Sephadex G-50 or Bio Gel P60 column equilibrated with 0.2 M ammonium bicarbonate at 0-4°C, and the conjugate eluted in the void volume was lyophilized.

Preparation of vaccine

2.0 mg of the conjugate thus prepared and 1.0 mg of nor muramyl dipeptide were dissolved in 0.6 mL of phosphate-buffered saline solution. Separately 0.6 mL of an oil mixture was prepared comprising 44 parts by weight of squalene, 41 parts by weight of squalane, 11 parts by weight of mannide monooleate and 4 parts by weight of aluminum monostearate. Emulsification was effected by hand using an apparatus comprising two glass syringes connected via a three-way stopcock. The buffer solution was placed in one syringe, the oil mixture in the

other, and after mixing the resultant mixture was passed back and forth at least 25 times until the resultant emulsion became quite viscous.

The vaccine thus produced was suitable for intramuscular injection in doses of 0.5-1.5 mL in humans.

Example 2

This Example illustrates the preparation of preferred antigenic conjugates of the present invention containing T-cell epitopes.

These conjugates were synthesized using the same solid state synthesis technique mentioned in Example 1 above. The T-cell peptide was synthesized first on the resin, then a spacer sequence of 4-5 amino acid residues containing a β-turn was added. Finally, the beta-HCG(109-145) peptide was synthesized on the N-terminal of the spacer sequence.

In a second method, a peptide was prepared having a terminal lysine. The primary amino group of the lysine was blocked, leaving the ε-amino group free. A T-cell or beta-HCG(109-145) peptide was synthesized as a side chain on the lysine ε-amino group, and back sequenced to assure the correct sequence. The blocking group on the lysine was removed and the main chain extended, with the last amino acid residue added being another lysine. The side chain synthesis was then repeated. Further repetitions of this procedure yielded a peptide containing two different T-cell epitopes and two beta-HCG(109-145) peptides.

Also, in a preferred process of this invention, on a resin using an Fmoc/ t-butyl technique was formed a β-strand template having the sequence:

Gly-Leu-Lys-Leu-Lys-Leu-Gly-COOH,

with both lysines having their ε-amino groups protected with Boc groups. The N-terminus of this template peptide was protected by the addition of Nps-Leu, and then the ε-blocking group was removed from the lysine adjacent the N-terminus of the peptide. Thereafter, a T-cell epitope was assembled on the free ε-amino group of the lysine using the Boc/benzyl technique described in the aforementioned U.S. patents. The N-terminus of the T-cell epitope was blocked by acetylation, and then the Npys protecting group was removed from the N-terminus of the template. The

main chain of the peptide was extended using the Fmoc/t-butyl technique to produce the sequence:

(Ac)Gly-Leu-Lys-Leu-Lys-Leu-Leu-Gly-Gly-Ser-Pro-Leu-
Gly-Leu-Lys-Leu-Lys-Leu-Gly-COOH,

in which, as indicated by "(Ac)" the N-terminus was protected by acetylation. (The Gly-Ser-Pro-Leu sequence provides a β-turn spacer in the template.) The ε-blocking group was removed from the lysine adjacent the N-terminus of the peptide, and a B-cell epitope was assembled on the free ε-amino group of the lysine using the Fmoc/t-butyl technique. The N-terminal of the B-cell epitope was blocked by acylation. Finally, the t-butyl and Boc protecting groups were removed with TFA, and then the peptide was cleaved from the resin by low/high HF treatment.

Conjugates containing the following T-cell epitopes were prepared by these two procedures:

a. amino acids 580-599 of tetanus toxoid;
b. amino acids 830-844 of tetanus toxoid;
c. amino acids 916-932 of tetanus toxoid;
d. amino acids 947-967 of tetanus toxoid;
e. amino acids 288-302 of measles virus protein;
f. amino acids 16-33 of hepatitis B viral protein; or
g. amino acids 317-336 of malaria CSP protein.

CLAIMS

1.A vaccine comprising:

an antigenic conjugate of a protein reproductive hormone, a fragment of such a hormone, or a peptide substantially immunologically equivalent to such a hormone or fragment;

an adjuvant; and

at least one oil,

the conjugate and adjuvant being dispersed in an aqueous medium to form an aqueous phase and this aqueous phase being emulsified with the at least one oil,

characterized in that the antigenic conjugate comprises the hormone, fragment or peptide conjugated with a chemically-modified diphtheria toxoid, and the aqueous phase is emulsified with a mixture of oils.

2. A vaccine according to claim 1 characterized in that the hormone, fragment or peptide is the beta subunit of human chorionic gonadotropin, a fragment thereof or a peptide substantially immunologically equivalent thereto.

3. A vaccine according to claim 1 characterized in that the fragment or peptide has a sequence corresponding to amino acids 109-145 of the beta subunit of human chorionic gonadotropin, or a sequence substantially immunologically equivalent thereto.

4. A vaccine according to any one of the preceding claims characterized in that the chemically-modified diphtheria toxoid is a reaction product of diphtheria toxoid with ethylenediamine.

5. A vaccine according to any one of the preceding claims characterized in that the antigenic conjugate comprises 20-30 peptides per 10^5 daltons of the chemically-modified diphtheria toxoid.

6. A vaccine according to any one of the preceding claims characterized in that the adjuvant is N-acetyl-D-glucosamine-3-yl-acetyl-L-ala-D-isoglutamine (nor muramyl dipeptide).

7. A vaccine according to any one of the preceding claims characterized in that the mixture of oils comprises squalene and squalane

8. A vaccine according to claim 7 further comprising at least one of mannide monooleate and aluminum monostearate.

9. A vaccine according to claim 8 characterized in that the mixture of oil comprises, by weight, from 35 to 45 percent of squalene, from 35 to 45 percent of squalane, from 6 to 16 percent of mannide monooleate and from 1 to 5 percent of aluminum monostearate.

10. A vaccine according to any one of the preceding claims characterized in that from 0.5 to 2.0 mg of the antigenic conjugate are present per ml of the final emulsion.

11. A vaccine according to any one of the preceding claims characterized in that from 0.2 to 1.0 mg of the adjuvant are present per ml of the final emulsion.

12. A vaccine according to any one of the preceding claims characterized in that it comprises substantially equal volumes of the aqueous phase and the mixture of oils.

13. A vaccine according to any one of the preceding claims characterized in that the aqueous phase is phosphate-buffered saline.

14. The use of a vaccine according to any one of the preceding claims for treating humans suffering from a malignant disease.

15. The use according to claim 14 for treating humans suffering from breast cancer, lung cancer, colon cancer, malignant melanoma or bladder carcinoma.

16. A process for generating antibodies to a protein or reproductive hormone and/or for generating lymphoma cells capable of expressing such antibodies, the process being characterized by administering to a mammal a vaccine according to of claims 1 to 13 and recovering the antibodies and/or lymphoma cells from the mammal.

17. Antibodies to a protein or reproductive hormone, lymphoma cells capable of expressing such antibodies, and hybridoma cells derived from such lymphoma cells, characterized in that the antibodies and/or lyphoma cells are generated by a process according to claim 16.

18. An antigenic conjugate of a protein reproductive hormone, a fragment of such a hormone, or a peptide substantially immunologically equivalent to such a hormone or fragment, characterized in that this hormone, fragment or peptide is coupled to an epitope peptide having the sequence of at least one T cell lymphocyte epitope of a protein foreign to the animal to be treated with the conjugate, or a sequence substantially immunologically equivalent thereto.

19. An antigenic conjugate according to claim 18 characterized in that the hormone, fragment or peptide is the beta subunit of human chorionic gonadotropin, a fragment thereof or a peptide substantially immunologically equivalent thereto.

20. An antigenic conjugate according to claim 19 characterized in that the fragment or peptide has a sequence corresponding to amino acids 109-145 or 111-145 of the beta subunit of human chorionic gonadotropin, or a sequence substantially immunologically equivalent thereto.

21. An antigenic conjugate according to any one of claims 18 to 20 characterized in that the epitope peptide has a sequence corresponding to, or substantially immunologically equivalent to:

a. amino acids 580-599 of tetanus toxoid;

b. amino acids 830-844 of tetanus toxoid;

c. amino acids 916-932 of tetanus toxoid;

d. amino acids 947-967 of tetanus toxoid;

e. amino acids 288-302 of measles virus protein;

f. amino acids 16-33 of hepatitis B viral protein; or

g. amino acids 317-336 of malaria CSP protein.

22. An antigenic conjugate according to any one of claims 18 to 21 characterized in that hormone, fragment or peptide is coupled to the epitope peptide via a spacer peptide containing from about 2 to about 8 amino acid residues.

23. The use of an antigenic conjugate according to any one of claims 18 to 22 to control fertility, or treat a malignant disease, in humans.

24. The use according to claim 23 for treating humans suffering from breast cancer, lung cancer, colon cancer, malignant melanoma or bladder carcinoma.

25. The use according to claim 23 or 24 of an mixture of two or more antigenic conjugates according to any one of claims 18 to 22.

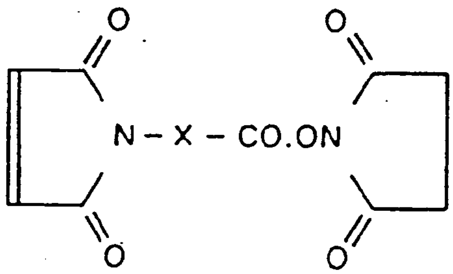
26. A process for preparing antibodies to a protein reproductive hormone and/or lyphoma cells capable of expressing such antibodies, which process comprises introducing into a mammal a modified polypeptide, thereby causing the formation of the antibodies in the mammal, and recovering the antibodies and/or lymphoma cells from the mammal, characterized in that the modified polypeptide used is an antigenic conjugate according to any one of claims 16 to 20.

27. Antibodies to a protein or reproductive hormone, lymphoma cells capable of expressing such antibodies, and hybridoma cells derived from such lymphoma cells, characterized in that the antibodies and/or lyphoma cells are generated by a process according to claim 26.

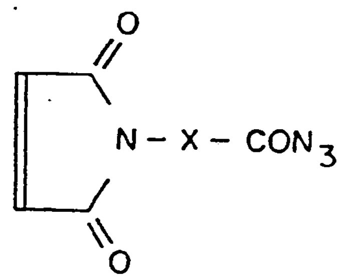
28. A process for determining the presence or absence of a protein in a mammal, or assaying the quantity of a protein in a mammal, which process comprises bringing body tissue or fluid from the mammal into contact with an antibody capable of reacting with the protein, and observing the formation or non-formation of a complex between the antibody and the protein, characterized in that the antibody used is produced by a process according to claim 26.

29. The use of an antibody, lymphoma cell or hydridoma cell produced by a process according to claim 26 to treat a disease in a mammal.

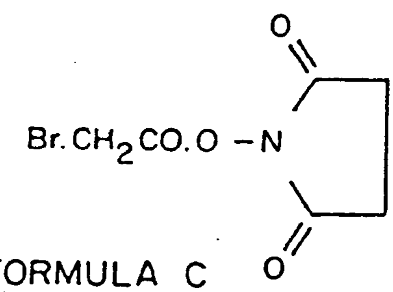
FIG. 1



FORMULA A



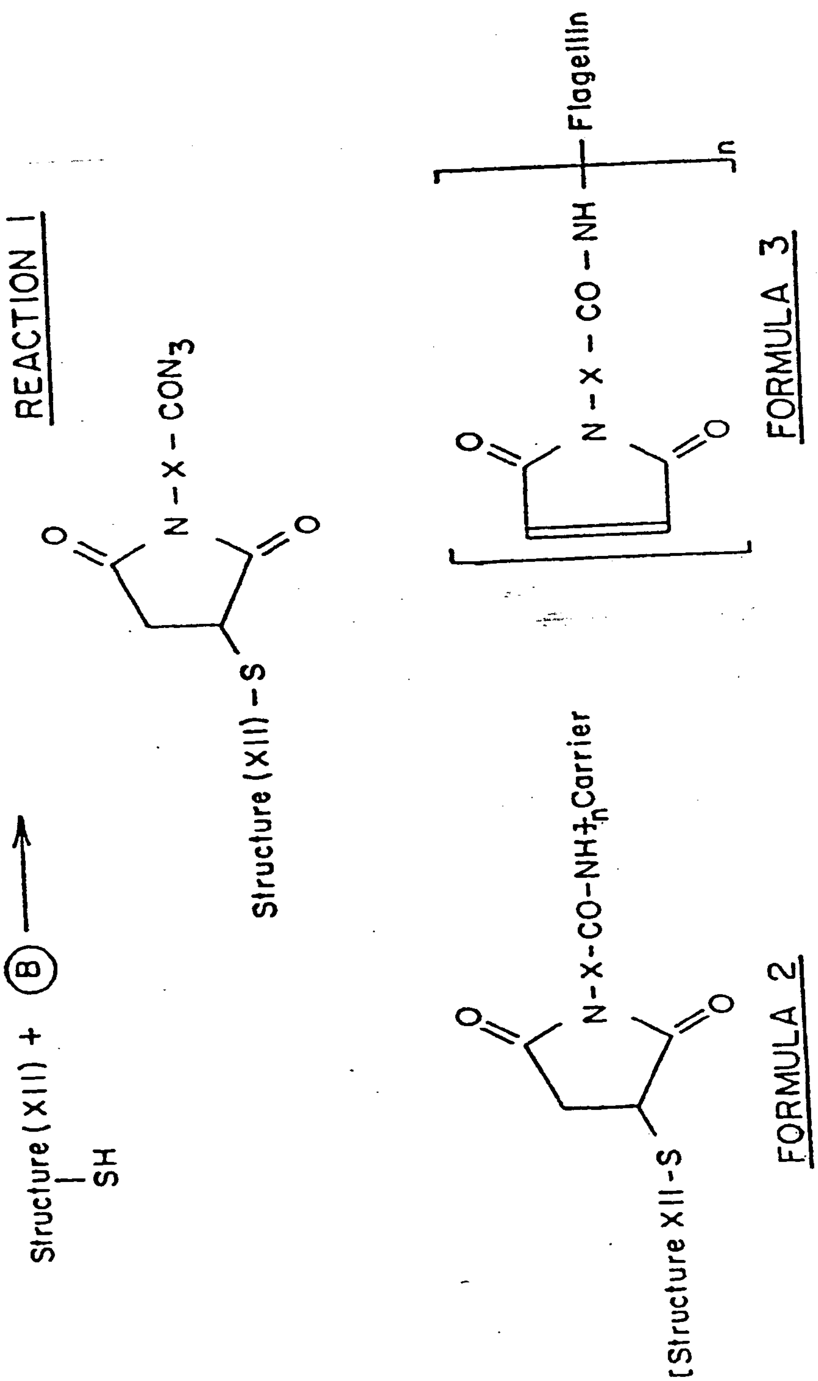
FORMULA B



FORMULA C

SUBSTITUTE SHEET

FIG. 2



SUBSTITUTE SHEET

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US92/08370

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :A61K 39/00, 37/38, 37/10, 37/02
US CL :424/88, 520; 530/387, 300+, 398; 514/8
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 424/88, 520; 530/387, 300+. 398; 514/8

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CAS/STN, DIALOG, APS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US, A, 4,201,770 (STEVENS) 6 MAY 1980, see entire document.	3,20 1-2, 4-13, 16-19, 21-23, 25-29
X Y	US, A, 4,302,386 (STEVENS) 24 November 1981, see entire document.	3,20 1-2, 4-13, 16-19, 21-23, 25-27
X Y	US, A, 4,384,995 (STEVENS) 24 May 1983, see entire document.	3, 20 1-2, 4-14, 21-29
X Y	US, A, 4,526,716 (STEVENS) 02 July 1985, see entire document.	3, 20 1-2, 4-19, 21-29

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be part of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 DECEMBER 1992	13 JAN 1993
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Facsimile No. NOT APPLICABLE	Telephone No. (703) 308-0196

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US92/08370

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US, A, 4,691,006 (STEVENS) 01 September 1987, see entire document.	3, 20 1-2, 4-19, 21-29
X Y	US, A, 4,855,285 (STEVENS) 08 August 1989, see entire document.	3, 20 1-2, 4-19, 21-29
X Y	US, A, 5,006,334 (STEVENS) 09 April 1991, see entire document.	3, 20 1-2, 4-19, 21-29
Y	US, A, 4,886,782 (GOOD ET AL) 12 December 1989, see entire document.	18, 21
Y	US, A, 4,882,145 (THORNTON ET AL) 21 November 1989, see entire document.	18, 21
X	JOURNAL OF GENERAL VIROLOGY, Volume 71, issued 1990, C.D. Partidos et al., "Prediction and identification of a T cell epitope in the fusion protein of measles virus immunodominant in mice and humans", pages 2099-2105, see page 2099.	21
X	EUROPEAN JOURNAL OF IMMUNOLOGY, Volume 20, issued 1990, P.C. HO ET AL., "Identification of two T cell epitopes from tetanus toxin", pages 477-483, see the abstract.	21
Y	US, A, 4,310,455 (BAHL) 12 January 1982, see column 11.	26-29
Y	AMERICAN JOURNAL OF OBSTERICS AND GYNECOLOGY, Volume 157, Part 2 of 4, issued October 1987, G.P. TALWAR ET AL, "Recent developments in immunocontraception", pages 1075-1076, see abstract.	25
Y	EOS, JOURNAL OF IMMUNOLOGY AND IMMUNO-PHARMACOLOGY, Volume 6, Part 2, issued 1986, V. C. STEVENS "State of the Art in immunological Fertility Control", pages 118-122, see page 121.	1-15
A	AMERICAN JOURNAL OF REPRODUCTIVE IMMUNOLOGY AND MICROBIOLOGY, Volume 8, No. 2, issued June 1985, D.C. COVEY ET AL, "A Candidate carrier Protein for beta-Human chorionic Gonadotropin: 54,000-Molecular-weight Fragment of Tetanus Toxin", pages 43-47.	18-23
A	E. A. Mortimer, "VACCINES" published 1988 by W. B. SAUNDERS COMPANY (Phil, Pa.), pages 31-44	1-5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US92/08370

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
Please See Extra Sheet.

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all se rchable claims. (Telephone Practice)

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite ayment of any addtional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search repo t covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention frist mentioned in the claims; it is covered by claims Nos.:

Remark on Protest
☐ The additional search fees were accompanied by the applicant's protest.
☐ No protest accompanied the payment of additional search fees.

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING

This ISA found multiple inventions as follows:

I. Claims 1-15, drawn to vaccine compositions and their use, classified in Class 424, subclass 88.

II. Claims 16-17, drawn to a process of preparing antibodies, classified in Class 530, subclass 387.

III. Claims 18-22, drawn to antigenic conjugate compositions, classified in Class 530, subclass 398.

IV. Claims 23-25, drawn to treatment of diseases, classified in Class 514, subclass 8.

V. Claims 26-27, drawn to process of preparing polypeptides, classified in Class 530, subclass 300+.

VI. Claims 28-29, drawn to use of antibody to treat human disease, classified in Class 424, subclass 520.

The claims of these five inventions are directed at different inventions which are not linked to form a single general concept.
Group I and II are related as product and process of use, in this case the process as claimed can be practiced with another materially different product such as synthetically manufactured peptide.
Group III and IV, V and VI, are related as product and process of use , in this case the product as claimed can be used in a materially different process such as a medium for affinity purification.
Likewise, Groups IV, V and VI are directed at divergent subject matter, as shown by their different classification. Also, Group I differs from Group II as not requiring the T cell epitopes and spacers of Group II.